Total Maximum Daily Load Assessment

Boggs Creek –COARMA18a, Pueblo County, CO

September 2015

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Table of Contents

Executive Summary

Information fundamental to Boggs Creek TMDL development is summarized in Table 1. The results of TMDL development are provided in Tables 2-4.

Table 1. TMDL Development Summary

<table>
<tr><td>Waterbody ID</td><td colspan="3">COARMA18a</td></tr>
<tr><td>Segment Description</td><td colspan="3">Mainstem of Boggs Creek from the source to Pueblo Reservoir</td></tr>
<tr><td>Pollutants Addressed</td><td colspan="3">Se (dissolved), U (total),</td></tr>
<tr><td rowspan="4">Designated Uses and Impairment Status</td><td colspan="2">Agriculture</td><td>Impaired</td></tr>
<tr><td colspan="2">Aquatic Life Warm1</td><td>Impaired</td></tr>
<tr><td colspan="2">Recreation E</td><td>Not Impaired</td></tr>
<tr><td colspan="2">Water Supply</td><td>Impaired</td></tr>
<tr><td>Size of Watershed</td><td colspan="3">Approximately 26.5 sq. mi (area delineated using USGS StreamStats), drains to Pueblo Reservoir</td></tr>
<tr><td>Land use</td><td colspan="3">Mixture of Ranch/rural and open space/river corridor</td></tr>
<tr><td rowspan="3">Source Identification</td><td>Parameter</td><td>Nonpoint Sources</td><td>Point Sources</td></tr>
<tr><td>Selenium</td><td>Irrigation ditch</td><td>None</td></tr>
<tr><td>Uranium</td><td>Irrigation ditch</td><td>None</td></tr>
<tr><td>Water Quality Goal</td><td colspan="3">Attainment of water quality standards and all designated uses.</td></tr>
<tr><td rowspan="4">Water Quality Target</td><td rowspan="2">Parameter</td><td colspan="2">Water Quality Standards (ug/L)</td></tr>
<tr><td>acute</td><td>chronic</td></tr>
<tr><td>Selenium</td><td>18.4</td><td>4.6</td></tr>
<tr><td>Uranium</td><td>--</td><td>30 (Trec)</td></tr>
<tr><td>Analysis/ Methodology</td><td colspan="3">Load Duration Curves were used to determine loading. Flow estimates were determined based on nearby streamgaging stations and watershed area using USGS Colorado StreamStats.</td></tr>
<tr><td>Margin of Safety (MOS)</td><td colspan="3">A 10% explicit margin of safety was included in this TMDL for all parameters.</td></tr>
</table>

Table 2. Selenium TMDL: **Monthly nonpoint source (load allocation) allowable loading and pollutant reductions necessary to meet the aquatic life-based selenium standard in Boggs Creek.**

Month	Se Target, WQ Standard (ug/L)	Se TMDL (lbs/day)	10% MOS (lbs/day)	Load Allocation (lbs/day)	Percent Reduction
Jan	4.6	0.088	0.009	0.079	73%
Feb	4.6	0.089	0.009	0.080	73%
Mar	4.6	0.085	0.009	0.077	36%
Apr	4.6	0.066	0.007	0.059	32%
May	4.6	0.126	0.013	0.113	31%
Jun	4.6	0.353	0.035	0.317	93%
Jul	4.6	0.151	0.015	0.136	30%
Aug	4.6	0.113	0.011	0.102	28%
Sep	4.6	0.055	0.005	0.049	31%
Oct	4.6	0.057	0.006	0.051	34%
Nov	4.6	0.080	0.008	0.072	73%
Dec	4.6	0.091	0.009	0.082	73%

Table 3. Uranium TMDL: **Monthly nonpoint source (load allocation) allowable loading and pollutant reductions necessary to meet the water supply based uranium standard in Boggs Creek.**

Month	U Target, WQ Standard (ug/L)	U TMDL (lbs/day)	10% MOS (lbs/day)	Load Allocation (lbs/day)	Percent Reduction
Jan	30	0.562	0.056	0.506	2%
Feb	30	0.572	0.057	0.515	2%
Mar	30	0.545	0.055	0.491	2%
Apr	30	0.420	0.042	0.378	1%
May	30	0.804	0.080	0.724	0.2%
Jun	30	2.258	0.226	2.032	1%
Jul	30	0.966	0.097	0.869	1%
Aug	30	0.724	0.072	0.652	1%
Sep	30	0.349	0.035	0.314	1%
Oct	30	0.364	0.036	0.327	1%
Nov	30	0.513	0.051	0.462	1%
Dec	30	0.581	0.058	0.523	2%

1.0 Introduction

Section 303(d) of the federal Clean Water Act requires states to identify water bodies that are water quality impaired. Water quality impaired segments are those water bodies or stream segments that are not fully attaining one or more assigned use classifications or standards. This segment is currently identified on the Colorado 2012 303(d) List for not meeting selenium, zinc and uranium water quality standards. Boggs Creek was initially on the Colorado 303(d) list in 2002 for selenium and zinc, and was later listed for uranium in 2008. Once listed, unless standards are attained through other mechanisms such as implementation activities, the original listing is shown to be in error or the standards have been changed, the State is required to quantify the amount of a specific pollutant that a listed water body can assimilate without exceeding applicable water quality standards. This maximum allowable pollutant quantity is referred to as the Total Maximum Daily Load ("TMDL").

The TMDL is comprised of the Load Allocation ("LA"), which is that portion of the pollutant load attributed to natural background or the nonpoint sources, the Waste Load Allocation ("WLA"), which is that portion of the pollutant load associated with point source discharges, and a Margin of Safety ("MOS"). The TMDL may also include an allocation reserved to accommodate future growth. The TMDL may be expressed as the sum of the LA, WLA, and MOS.

There are no point source discharges to the Boggs Creek drainage. Future point source discharges are also not anticipated. Therefore, the TMDLs include only allocations to address LA and MOS component.

1.1 Segment Description

Boggs Creek is tributary to Pueblo Reservoir, an on-channel reservoir sited on the Arkansas River mainstem. The Boggs Creek watershed lies to the south and west of Pueblo, Colorado, flowing in a northerly direction to the reservoir. The geographic extent of the watershed includes the surrounding area that drains to Boggs Creek, from its source to the confluence with Pueblo Reservoir (Figure 1).
Boggs Creek is an ephemeral stream, flowing in direct response to precipitation events and, during dry weather, when there is sufficient groundwater to recharge the stream channel.

The Boggs Creek watershed is underlain by cretaceous marine shale. The majority of the watershed is underlain by calcareous limestone and shale composing the Niobrara formation. The uppermost portion of the watershed is composed of Carlile shale, Greenhorn limestone and Graneros shale (Scott et all, 1978). These, and similar cretaceous shales are significant sources of selenium loading throughout the west. Both selenium and uranium are introduced into surface waters in areas underlain by these marine shales as a result of weathering of the shale layers. (Gates, et al, 2009)

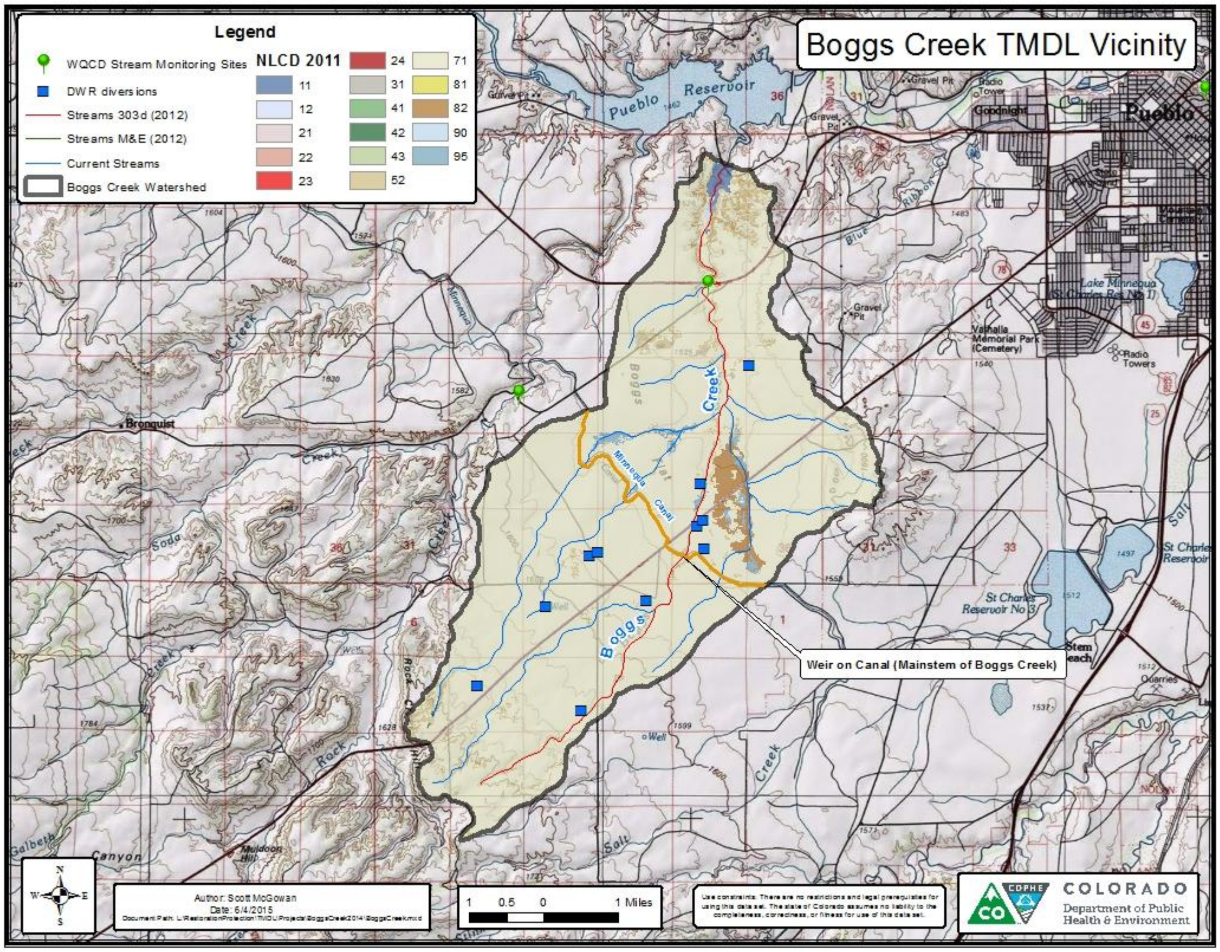

Figure 1-1. Boggs Creek and vicinity

1.2 Land Use

Land use may significantly impact surface water quality. Seepage associated with unlined irrigation ditches, ponds and septic tanks, as well as irrigation of agricultural and residential development increases the amount of water mobilizing selenium and uranium from shale derived soils and the underlying shale strata. The Boggs Creek drainage is largely undeveloped and hosts a few widely scattered residential properties. There is an unlined man-made irrigation ditch that runs through the entire Boggs Creek watershed. There are not currently, nor have there been, any Colorado Discharge Permit System (CDPS) or National Permit Discharge Elimination System (NPDES) permits that discharge to Boggs Creek. Below is a future land use map of the area (Pueblo Comprehensive Plan, 2008) which includes rural/ranch land south of Highway 96 and open space/river corridor north of the highway. The land use in the area is not projected to change in the next 15years.

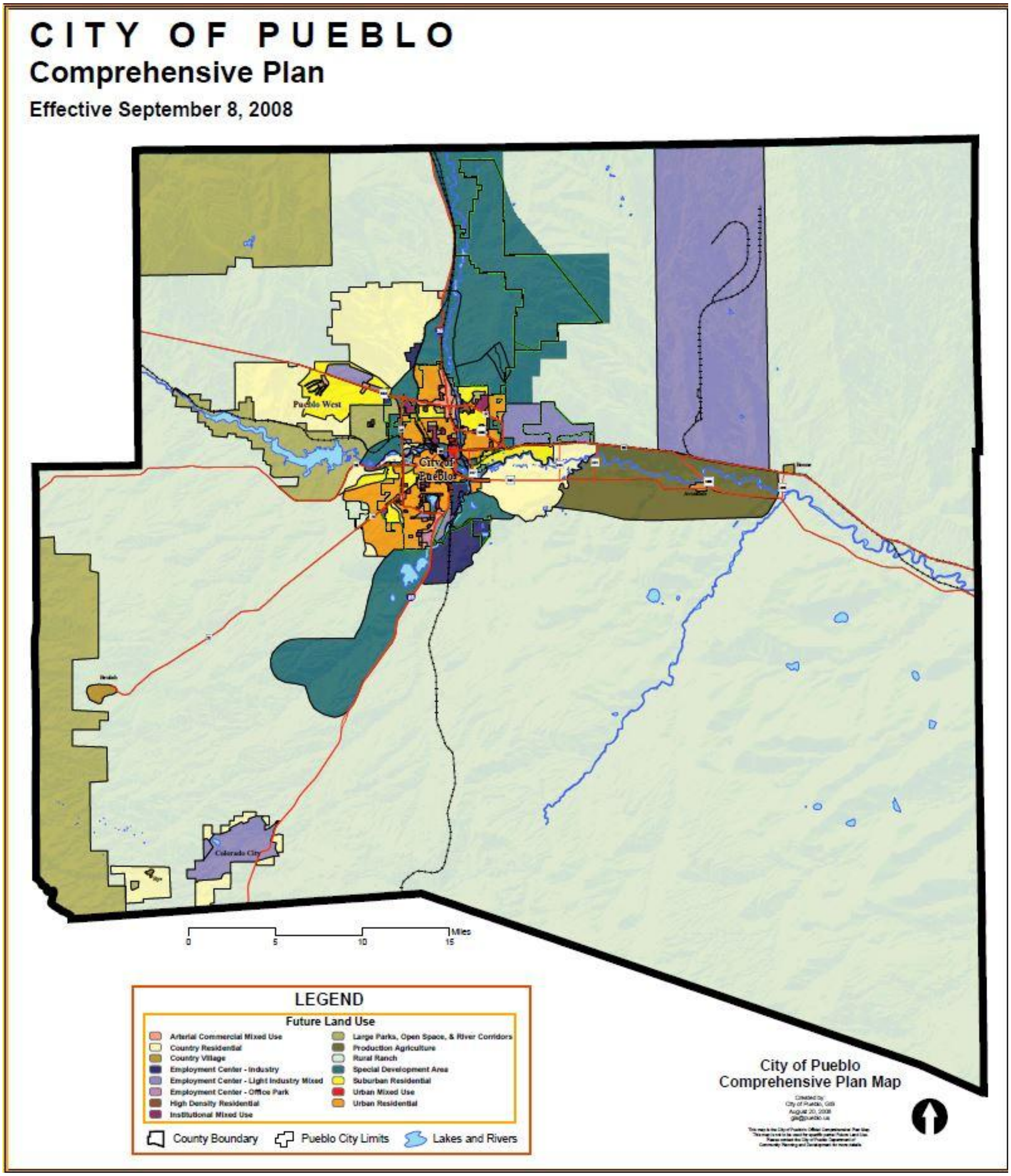

Figure 1.2-1: Future Land Use of Pueblo County from the Pueblo Comprehensive Plan, 2008, details growth expectations and patterns through 2030.

2.0 Water Quality Standards

Waterbodies in Colorado are divided into discrete units or "segments". The Colorado *Basic Standards and Methodologies for Surface Water*, Regulation 31, (WQCC 2008a) discusses segmentation of waterbodies in terms of several broad considerations:

> *31.6(4)(b)…Segments may constitute a specified stretch of a river mainstem, a specific tributary, a specific lake or reservoir, or a generally defined grouping of waters within the basin (e.g., a specific mainstem segment and all tributaries flowing into that mainstem segment.*
>
> *(c) Segments shall generally be delineated according to the points at which the use, physical characteristics or water quality characteristics of a watercourse are determined to change significantly enough to require a change in use classifications and/or water quality standards*

As noted in paragraph 31.6(4)(c), the use or uses of surface waters are an important consideration with respect to segmentation. In Colorado there are four categories of classified uses: aquatic life use; recreational use; agricultural use; and water supply use. A segment may be designated for any or all of these "use Classifications":

Each assigned use is associated with a series of pollutant specific numeric standards. These pollutants may vary and are relevant to a given classified use. Numeric pollutant criteria are identified in sections 31.11 and 31.16 of the *Basic Standards and Methodologies for Surface Water.*

2.1 Uses and Standards Addressed in this TMDL

The uses and numeric standards assigned for Boggs Creek, segment COARMA18a, are identified in the *Classifications and Numeric Standards for Arkansas River Basin*, Regulation No. 32 (WQCC 2010).

WBID	Segment Description	Designated Uses
COARMA18a	Mainstem of Boggs Creek from the source to Pueblo Reservoir	Aquatic Life Warm 1 Recreation E Agriculture Water Supply

Table 2.1-1. Designated uses and impairment status for Boggs Creek.

This segment, Middle Arkansas River sub-basin 18a, is included in the current *Section 303(d) List of Impaired Waters* (WQCC 2012) due to non-attainment of aquatic life use-based selenium and zinc standards. Similarly, agricultural use-based standards for selenium and water supply use-based standards for selenium and uranium are not attained. Water quality standards associated with the recreational use designation are attained and that use is fully supported. Table 2.1-2 summarizes the assigned uses and their attainment status. Table 2.1-3 identifies the relevant numeric standards assigned for segment COARMA18a.

Parameter	Aquatic Life warm 1	Recreation E	Water Supply	Agriculture
selenium	impaired	na[1]	impaired	impaired
uranium	not impaired	na	impaired	not impaired
zinc	not impaired	na	not impaired	not impaired

[1] no assigned standard associated with this use

Table 2.1-2. Designated uses and impairment status for Boggs Creek.

Parameter[1]	Classified Use			
	Aquatic Life[2]		Agriculture[3]	Water Supply[3]
	acute	chronic		
selenium	18.4	4.6	20	50
uranium	$=e^{(1.1021[\ln(hardness)]+2.7088)}$	$=e^{(1.1021[\ln(hardness)]+2.2382)}$	--	30
zinc	$=0.978e^{(0.9094[\ln(hardness)]+0.9095)}$	$=0.986e^{(0.9094[\ln(hardness)]+0.6235)}$	2000	5000

[1] values in µg/L
[2] expressed as dissolved fraction
[3] expressed as total recoverable fraction

Table 2.1-3. Numeric standards for 303(d) listed parameters for Boggs Creek

Chronic and acute aquatic life use-based standards are designed to protect against different ecological effects of pollutants (long term exposure to relatively lower pollutant concentrations vs. short term exposure to relatively higher pollutant concentrations). Chronic standards represent the level of pollutants that protect 95 percent of the genera from chronic toxic effects of metals. Chronic toxic effects include but are not limited to demonstrable abnormalities and adverse effects on survival, growth, or reproduction (WQCC 2006b).

Per the *Section 303(d) Listing Methodology, 2012 Listing Cycle* (WQCD 2010), attainment of Aquatic Life Use-based metals standards, when expressed as the dissolved fraction, is determined by comparison of the 85th percentile value of the ranked data against the standard.

Agriculture and Water Supply Use-based standards are expressed as a single value and reflect the total or total recoverable metals fraction. Per the *Section 303(d) Listing Methodology, 2010 Listing Cycle* (WQCD 2009), attainment of metals standards, when expressed as the total or total recoverable fraction, is determined by comparison of the 50th percentile value of the ranked data against the standard.

2.2 Listing History

Boggs Creek was initially included on the 2002 Section 303(d) List due to non-attainment of aquatic life use-based selenium and zinc standards, water supply use-based selenium, and agriculture use-based selenium standards. And later identified to be in non-attainment of water supply use-based uranium standard in the 2008 listing cycle. The listing assessment cites water quality data collected from August 2005 through June 2006, although additional sampling has been performed by the WQCD since March, 1998. These earlier samples were not utilized for the 303(d) listing decision assessment because the *Section 303(d) Listing Methodology – 2008 Listing Cycle*, as well as more recent iterations of the Listing Methodology, specifies that the assessment utilized the most recent five years of data for the listing decision analysis. All samples were collected at WQCD station 7285 on Boggs Creek at Highway 96.

Boggs Creek is remains on the 2012 Section 303(d) List due to non-attainment of selenium, uranium and zinc standards. TMDLs have been developed for selenium and uranium. Boggs Creek is in attainment of all assigned zinc standards, and therefore, a TMDL was not warranted at this time.

3.0 Problem Identification

Boggs Creek is an ephemeral stream, flowing in direct response to precipitation events and, during dry weather, when there is sufficient groundwater to recharge the stream channel. The Boggs Creek watershed is underlain by cretaceous marine shale (Figure 2). The majority of the surficial formations are composed of calcareous limestone and shale, the Niobrara formation, identified as *Qg Cretaceous* in Figure 2. The upper reaches of the watershed are characterized by older deposits of Carlile shale, Greenhorn limestone and Graneros shale (*Kn Cretaceous*). Together, with several other geologic strata, these sedimentary deposits comprise the Pierre Shale (Scott, et al, 1978).

Like the Mancos shale of western Colorado, the Pierre shale is classified as a cretaceous marine shale. Such deposits are often referred to as seleniferous shales due to their selenium content and are widely distributed throughout the western United States. Soils derived from underlying seleniferous shales also serve as selenium source material. Selenium is present in several different chemical forms in the soil. In alkaline soils, which are prevalent in much of Colorado and in the Boggs Creek drainage, selenium is predominantly found as selenate (SeO_4^{-2}). This species of selenium is not strongly bound to oxides and other minerals in the soil. As such, it is highly soluble. (Gates, et al, 2009)

Uranium is also present in both the Pierre shale as well as the shale derived soils of the Boggs Creek watershed. Like selenium, the mobility of uranium in soil is influenced by soil properties including pH and redox potential, and soil chemistry within the Boggs Creek drainage tends to facilitate solubility and, consequently, transport of uranium.

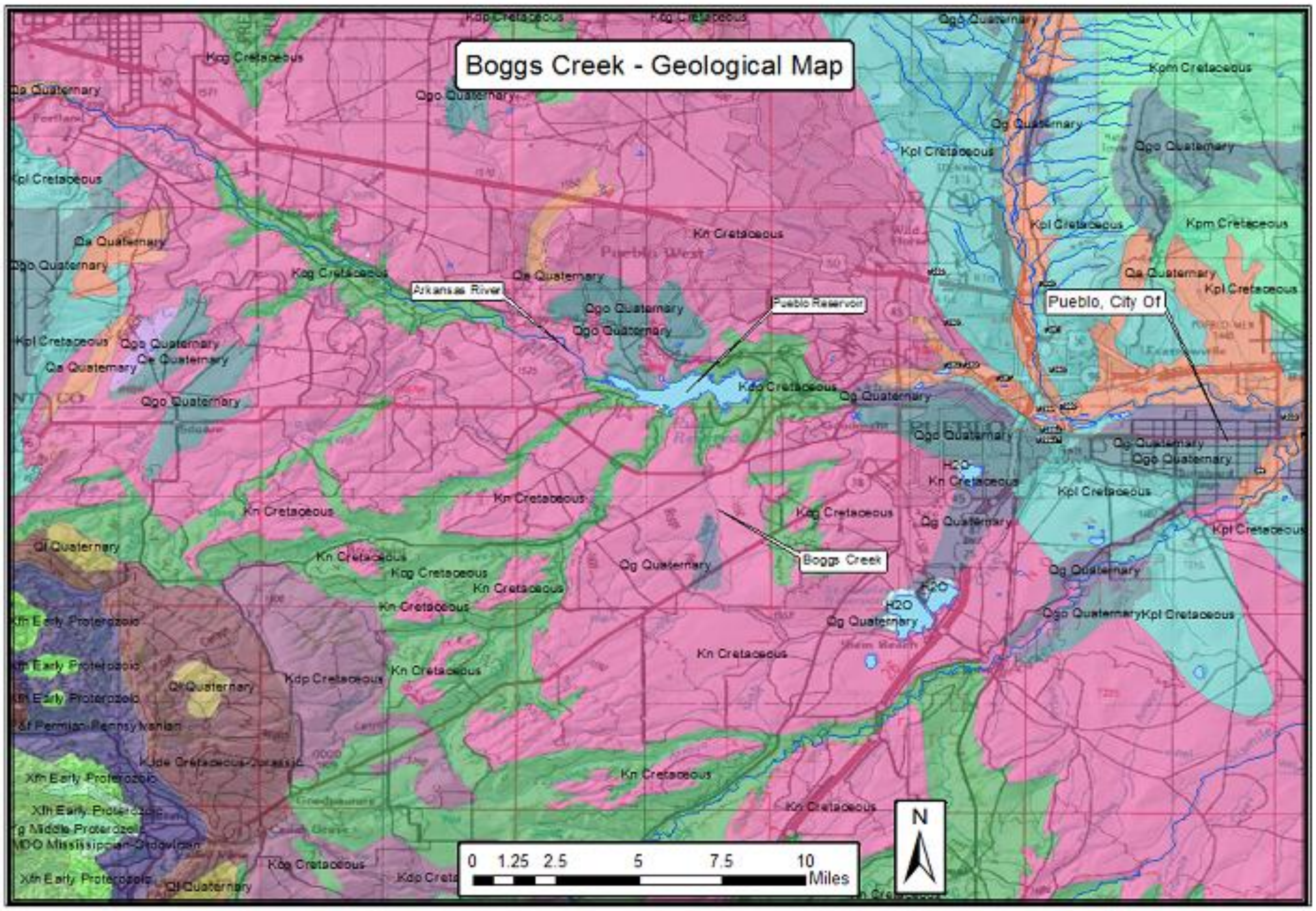

Figure 3-1. Boggs Creek Watershed – Surficial Geology

Soils in the upper watershed, predominantly Manville clay loam, are fairly deep and exhibit a relatively low degree of permeability. The low amount of precipitation in the watershed, in combination with the water storage capacity limits surface water flows in the upper watershed. During recent WQCD sampling in the watershed (2010 – 2012) no surface water was observes in the upper watershed. Lower in the drainage the physiography is characterized by deeply incised gullies, exposing the limestone and shale strata which underlay the entire watershed. The predominant soil type in the lower watershed is the Penrose-Minnequa complex and is shallow and rapidly draining (USDA, 1979). The portion of Boggs Creek from a point immediately above the WQCD sampling location at Highway 96 to the Lake Pueblo State Park has been observed to flow periodically, in response to precipitation or, during dry weather, as a result of groundwater recharge.

Figure 3-2. Boggs Creek above Lake Pueblo State Park

Groundwater which leaches to the relatively impermeable shale deposits tends to dissolve selenium and uranium and, as it flows atop the bedrock strata towards surface drainages, carries elevated levels of dissolved selenium and uranium with it. Various anthropogenic activities accelerate the mobilization and transport of selenium and uranium from shale and shale derived soil to surface water (Gates, et al, 2009). The Minnequa canal transports a significant amount of water, flowing southeast (approximately 5 miles) through the Boggs Creek drainage, upstream from the sampling location. The flow diverted from the Arkansas near Florence, CO travels approximately 11 miles before reaching the Boggs Creek drainage. Canal seepage increases the amount of water mobilizing selenium and uranium from shale derived soils and the underlying shale strata.

4.0 Water Quality Goals and Targets

The water quality target and goal for this TMDL is attainment of the current aquatic life use-based selenium and water supply use-based uranium standards

5.0 Instream Conditions

5.1 Hydrology

The hydrology of the Boggs Creek drainage is driven primarily by recharge of soils overlying shallow cretaceous shales. These shallow, highly permeable soils contribute to a relatively rapid cycle of soil moisture recharge in response to precipitation and subsequent discharge to Boggs Creek. Coupled with the general lack of precipitation which characterizes the region (Table 5-1), flows in Boggs Creek are ephemeral and, when flowing, at a consistent flow rate.

Month	Precipitation (inches)
Jan	0.3
Feb	0.3
Mar	0.8
Apr	0.9
May	1.2
Jun	1.2
Jul	2.1
Aug	2
Sep	0.9
Oct	0.6
Nov	0.4
Dec	0.4
Annual	**11.2**

Source http://www.climate-zone.com/climate/united-states/colorado/pueblo/

Table 5-1. Monthly and annual precipitation for Pueblo, CO.

In order to estimate flow for the purposes of using daily flow data over a ten year period, USGS StreamStats was used. This allows one to easily delineate a drainage area with an online map application and use a comparable gaging station in the area. In this case, upstream and downstream USGS gaging stations were evaluated, and the nearest comparable gaged flow is a USGS gage #09096000 (Arkansas River at Canon City, CO), upstream of Pueblo Reservoir. The gage location has similar elevation, climate and geology of the Boggs Creek watershed. The area of the upstream watershed is 3117 square miles, Boggs Creek watershed is 26.5 square miles, and the ratio of watershed areas is 117.6:1. Thus, the flow factor used in calculating estimated flows from the streamgage was 0.0085. USGS StreamStats generates Peak-

Flow, Flow-Duration and General Flow statistics using the entire period of record. The tables below summarize information.

Division sampling station 7285, Boggs Creek at Highway 96, was visited at least quarterly between May 2010 and May 2012. Samples were collected on four occasions (5/11/10, 6/21/10, 10/6/10 and 5/18/12). There was no instream flow during the other sampling visits.

Parameter	Value
6-hour, 100-yr precipitation, in inches	3.51
Mean basin slope computed from 10 m DEM, in percent	4.37
Area that drains to a point on a stream, in square miles	26.5
Mean Basin Elevation, in feet	5180
Mean annual precipitation, in inches	13.63
Percentage of basin above 7500 ft elevation	0

Table 5-2 USGS SteamStats Basin Characteristics Report

The flow gage used has a typical hydrograph for the Arkansas basin, with peak flows occurring in the summer months. There is significantly more variation in the flow percentiles during high flow season (May, June, and July), whereas, the shoulder and low flow months (September through April) have low variation consistently below 5 cfs.

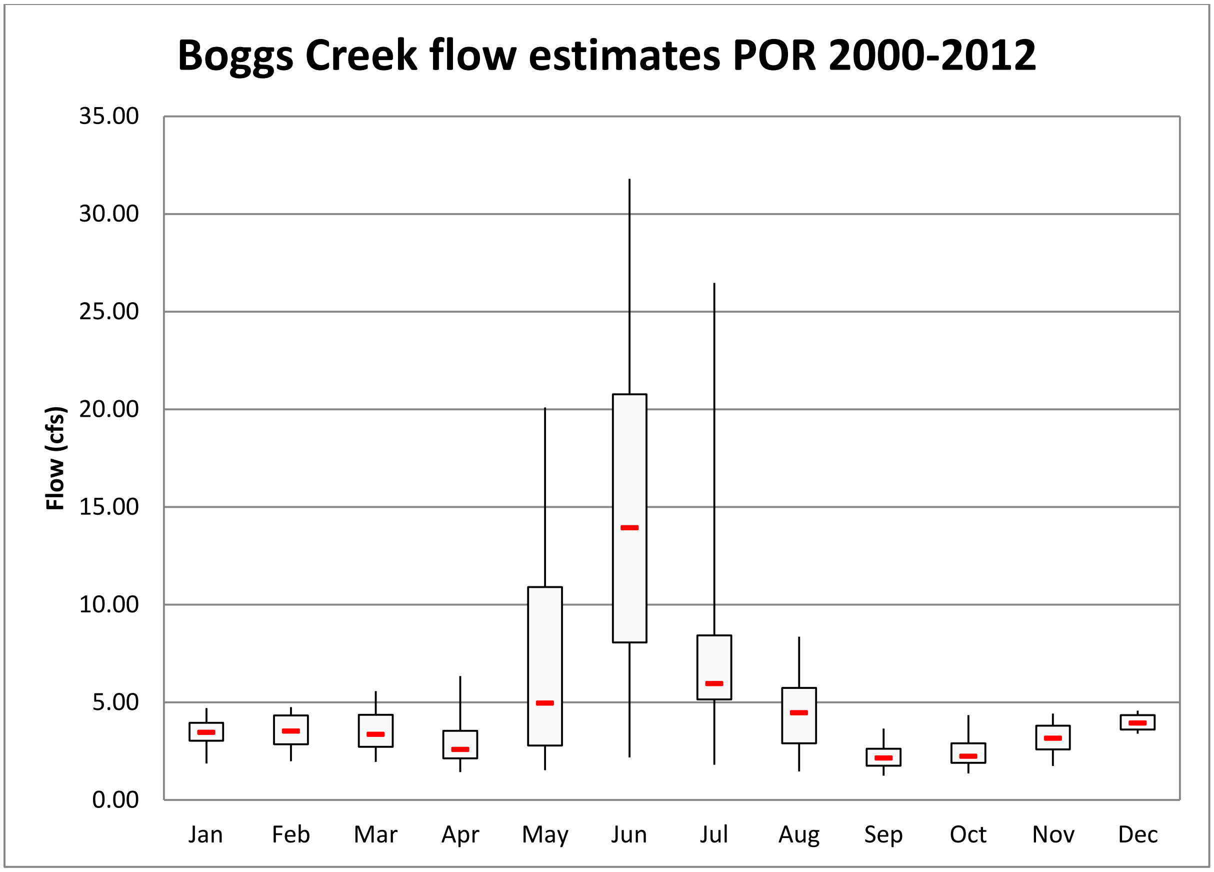

Figure 5-1: Statistical representation of monthly flows from 2000 through 2012. The box and whisker plots include the 5th, 25th, 75th, 95th percentiles of monthly flows over a 12 yr period. The red lines are the median flows for each month.

5.2 Ambient Water Quality

Aquatic life use-based selenium standard are expressed as dissolved concentrations, while the water supply use-based uranium standard is expressed as total recoverable fraction. The aquatic life use-based standards for selenium are expressed as numeric values, 4.6 µg/L (chronic) and 18.4 µg/L (acute)Water quality sample data collected between 2005 and the present, consistently (5 of 7 samples) exceed the acute standard as well as the chronic standard. All data collected can be seen in Appendix A.

Attainment of chronic dissolved metal standards is determined by comparison of the 85th percentile value of the ranked data against the standard (see *Section 303(d) Listing Methodology – 2012 Listing Cycle*, WQCC 2011), while attainment of the total recoverable uranium is determined by comparing the 50th percentile against the standard.

month	chronic Se TVS[1]	ambient Se[1]	U[1] TVS	ambient U[1]
Jan	4.6	**<u>311</u>**[2]	30	**<u>68</u>**
Feb	4.6	**<u>312</u>**[2]	30	**<u>68</u>**
Mar	4.6	**<u>155</u>**	30	**<u>71</u>**
Apr	4.6	**<u>141</u>**	30	**<u>62</u>**
May	4.6	**<u>136</u>**	30	**<u>32</u>**
Jun	4.6	**<u>396</u>**	30	**<u>41</u>**
Jul	4.6	**<u>130</u>**	30	**<u>43</u>**
Aug	4.6	**<u>123</u>**	30	**<u>45</u>**
Sep	4.6	**<u>135</u>**[2]	30	**<u>53</u>**
Oct	4.6	**<u>148</u>**	30	**<u>60</u>**
Nov	4.6	**<u>311</u>**	30	**<u>65</u>**
Dec	4.6	**<u>311</u>**[2]	30	**<u>68</u>**

Table 5.2-1. Attainment/Exceedances of Monthly Chronic Water Quality Standards (exceedances in bold and underlined)

[1] metal values in µg/l

2 Sample data not available for month. Values calculated as averages of data for preceding and following months

6.0 Technical Analysis

6.1 Load Duration Curve

Load duration curves are a graphical tool used to illustrate the relationships between flow and water quality. First a flow duration curve is estimated using daily flows were calculated using the flow factor, and data from 2000-2012 for USGS gage #09096000 (Arkansas River at Canon City, CO). The flow data was then ranked According to the EPA 841-B-07-006 document:

"The use of "percent of time" provides a uniform scale ranging between 0 and 100. Thus, the full range of stream flows is considered. Low flows are exceeded a majority of the time, while floods are exceeded infrequently.

A basic flow duration curve runs from high to low along the x-axis. The x-axis represents the duration amount, or "percent of time", as in cumulative frequency distribution. The y-axis represents the flow value (e.g. cubic feet per second) associated with the "percent of time" (or duration) it is met or exceeded…"

Flow duration curves represent the percent of time a flow is likely to be equaled or exceeded within the stream based on historic flow data. This allows for the grouping of flow conditions, in this case into five general indicator categories. The "high-flow" category represents flows observed during the greatest 10 percent of all flow values; ‘moist conditions’ represents flow values observed 30 percent of the time (they are equaled or exceeded 10-40 percent of the time); ‘mid-ranges’ represents 20 percent of all flows (equaled or exceeded 40-60 percent of the time); ‘dry-conditions’ represents 30 percent of all flows (equaled or exceeded 60 to 90 percent of the time); and ‘low-flow’ conditions exist about 10 percent of the time, with 90 to 100 percent of all flows equaling or exceeding those in the low flow category.

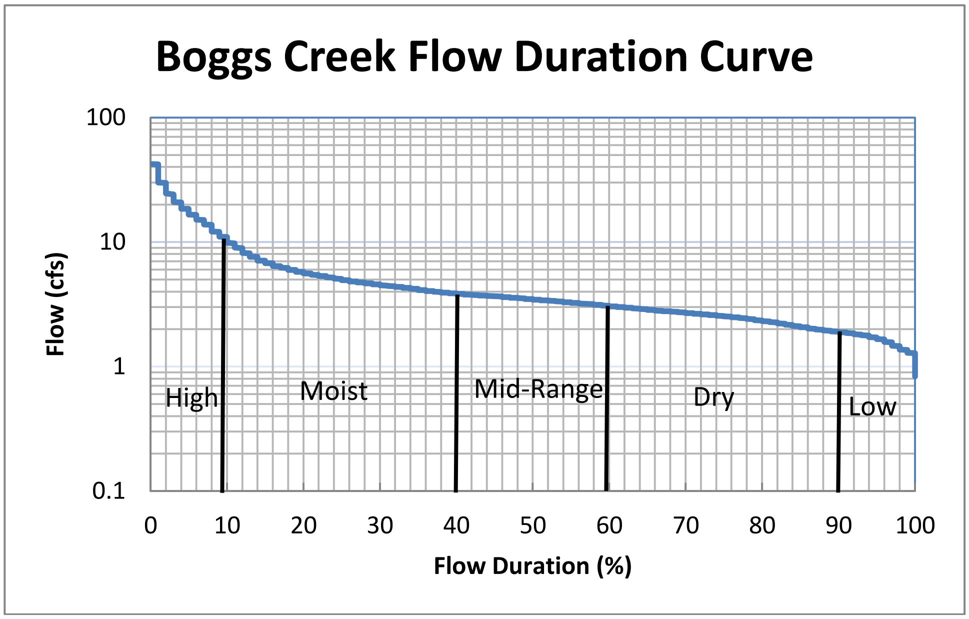

Figure 6.1-1 Boggs Creek Flow Duration Curve, using USGS gage #09096000 (Arkansas River at Canon City, CO)

The load duration curve is then calculated by multiplying stream flow with the numeric water quality standard and a conversion factor resulting a in a curve that represents the water quality standard in lbs per day for a particular pollutant of concern. Ambient water quality data is then plotted, with an associated flow measurement to compute an instantaneous load. The pattern that emerges on a LDC can indicate the source of impairment. For instance, loading that is constant across all flow regimes can indicate a point source problem. Or impairments only observed in the high flow range can indicate a non-point source problem associated with a storm event.

Load duration curves were developed for selenium, uranium and zinc.
The selenium load duration curve (Figure 6.1-2) shows consistent loading across all flow regimes. There are no emerging patterns that point to high or low flow issues, runoff or seasonal irrigation return flow. Because a portion of the flow during all flow regimes is dependent on the groundwater table, selenium loading most likely comes from groundwater recharge and release of selenium through the soil.

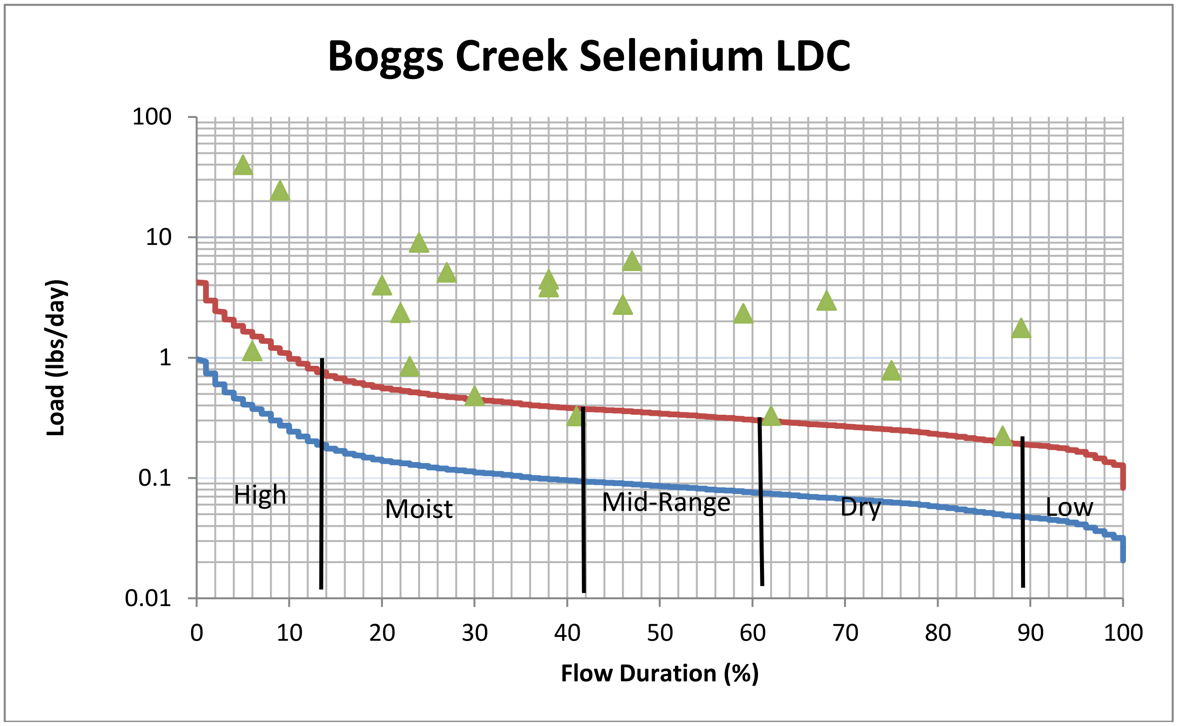

Figure 6.1-2- Selenium exceedances shown in all flow regimes (green triangles). Red line represents the acute standard, and the blue line represents the chronic standard.

Uranium reductions are needed in all flow regimes. The load duration curve does not show any possible high or low flow issues, or illustrate consistent loading from a possible point source.

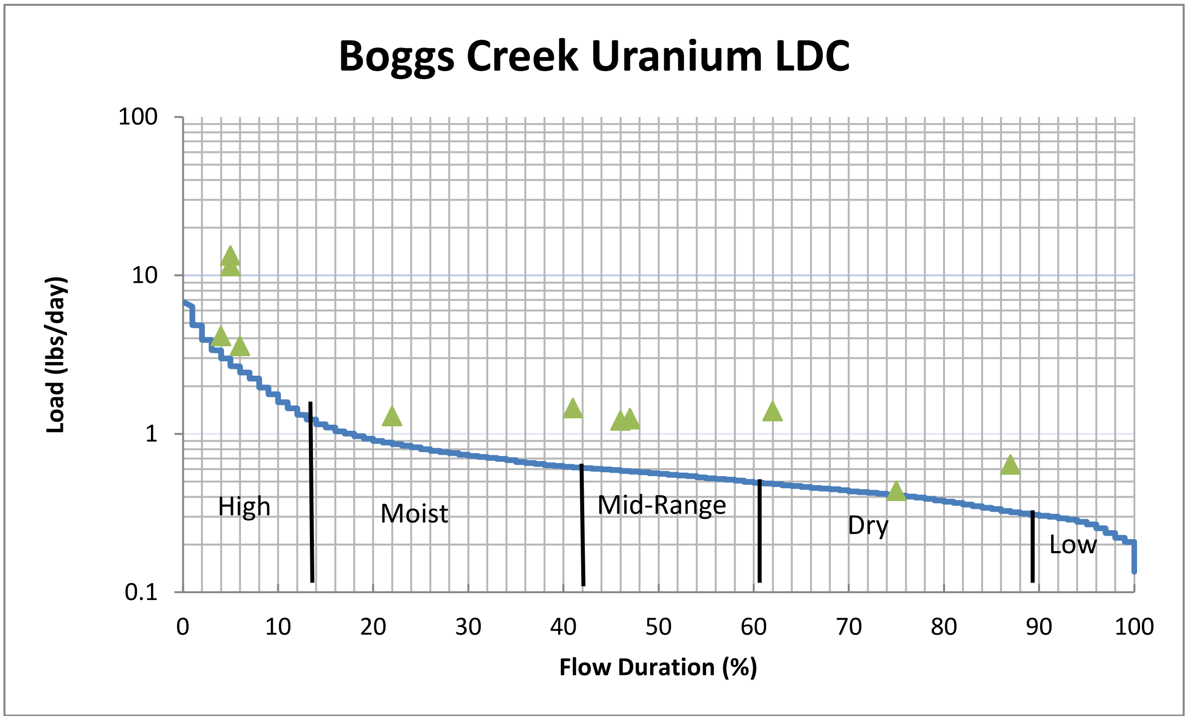

Figure 6.1-3- Uranium exceedances shown in all flow regimes (green triangles). The blue line represents the chronic uranium standard

6.2 Point Sources

There are no NPDES or CDPS permitted point source discharges in the Boggs Creek drainage. The Pueblo Area Council of Governments Comprehensive Plan indicates the entire Boggs Creek drainage watershed is zoned as rural/ranching. Anticipated growth for Pueblo over the next 15 years is less than 2% (Pueblo Comprehensive Plan, 2008). Given the land use, and growth projections, no reserve capacity has been assigned in this TMDL for future dischargers, as this would be unlikely.

6.3 Non-Point and Natural Sources

The Boggs Creek drainage is predominantly underlain by cretaceous marine shale which is source material for both selenium and uranium found in Boggs Creek. Seepage from the Minnequa canal has been identified as a potential source affecting the fate and transport of selenium and uranium to surface water. As previously stated, there is no identifiable source for the (former) zinc impairment.

7.0 TMDL Allocation

7.1 Total Maximum Daily Loads

TMDLs are required in instances where waterbodies fail to support classified uses and/or attain assigned numeric water quality standards. The TMDL calculates the pollutant load reductions required to attain water quality standards. The load reductions are apportioned among MOS, WLA and LA. The WLA represents pollutant contributions from permitted and non-permitted point source discharges. The LA is comprised of nonpoint source and/or background contributions. The TMDL may be expressed as the sum of the LA, WLA and MOS.

$$TMDL = WLA + LA + MOS$$

TMDL = Sum of Waste Load Allocations + Sum of Load Allocations + Margin of Safety

7.1.1 WLA

There are no permitted point source discharges in the Boggs Creek drainage. Therefore there are no waste load allocations calculated for this TMDL. As mentioned earlier, there is no anticipated future permitted discharge(s) to Boggs Creek; therefore, no reserve capacity was included in this TMDL.

7.1.2 LA

All sources that were examined (i.e. natural geology of the area and hydrology of Boggs Creek) are considered nonpoint sources and are therefore accountable to load allocations. Similarly, all load reductions are required from nonpoint sources.

7.1.3 MOS

According to the Federal Clean Water Act, TMDLs require a MOS component that accounts for the uncertainty about the relationship between the pollutant loads and the receiving waterbody. The MOS can be implicit or explicit. A 10% explicit margin of safety was included in this TMDL. This MOS is included to account for the uncertainty between the TMDL load allocations and the desired water quality target. The MOS used in the TMDL analysis is explicit (10%) and also resides in the comparison of chronic load reductions applied to acute standard exceedances. Conservative assumptions used in the analysis include the use of the 85th percentile of the data in establishing ambient conditions, per the 303(d) Assessment Methodology.

The TMDL equation becomes the following:

$$TMDL = \sum LA + MOS$$

Where,
LA (lbs/day) = Water Quality Standard (μg/l) x Flow (cfs) x Conversion Factor - MOS

Conversion factor (CF):

$$\left(\frac{\mathrm{ft}^3}{\mathrm{sec}}\right)\left(\frac{\mu\mathrm{g}}{\mathrm{L}}\right) \rightarrow \frac{\mathrm{lbs}}{\mathrm{day}}$$

CF =

$$\left(\frac{ft^3}{sec}\right)\left(\frac{60\ sec}{1\ min}\right)\left(\frac{60\ min}{1\ hr}\right)\left(\frac{24\ hr}{1\ day}\right)\left(\frac{28.32\ L}{ft^3}\right)\left(\frac{\mu g}{L}\right)\left(\frac{g}{10^6 \mu g}\right)\left(\frac{0.002205\ lbs}{g}\right)$$

$$=0.0054$$

7.2 TMDL for Dissolved Selenium

The entire TMDL is expressed as a Load Allocation, meaning that all pollutant reduction necessary to attain standards are from nonpoint sources.

In order to attain chronic selenium standards, Boggs Creek would require higher reductions in selenium loading in the winter low flow conditions, November thru February (73%), and June (93%) which reflect the highest monthly selenium concentrations. Because there is limited data for the winter low flow months, ambient water quality concentrations were set at the same value for each month (Nov-Feb). The remaining months will require a more moderate reduction, around 30%.

Comparison of individual sample values, when adjusted by the appropriate monthly loading reductions against the corresponding acute selenium standards, indicates that acute selenium standards would be achieved with the exception of a single sample result. State assessment protocol, as defined in the *Section 303(d) Listing Methodology – 2012 Listing Cycle,* requires individual sample results not exceed the corresponding acute standard at a frequency greater than one exceedance within a three year period. A single exceedance within the period of record assessed would be considered to demonstrate attainment of the acute standard. The calculated load reductions are therefore protective of both acute and chronic zinc standards.

Month	Median (cfs)	Se Standard (µg/L)	Se TMDL (allowable load, lbs/day)	10% MOS	Load Allocation (lbs/day)	Current Conditions (ambient WQ, µg/L)	Current Load (lbs/day)	Load Reduction (lbs/day)	Percent Reduction
Jan	3.5	4.6	0.088	0.009	0.079	311	5.829	5.75	73%
Feb	3.5	4.6	0.089	0.009	0.080	312	5.950	5.87	73%
Mar	3.4	4.6	0.085	0.009	0.077	155	2.825	2.75	36%
Apr	2.6	4.6	0.066	0.007	0.059	141	1.974	1.91	32%
May	5.0	4.6	0.126	0.013	0.113	136	3.642	3.53	31%
Jun	13.9	4.6	0.353	0.035	0.317	396	29.809	29.49	93%
Jul	6.0	4.6	0.151	0.015	0.136	130	4.186	4.05	30%
Aug	4.5	4.6	0.113	0.011	0.102	123	2.960	2.86	28%
Sep	2.2	4.6	0.055	0.005	0.049	135	1.572	1.52	31%
Oct	2.2	4.6	0.057	0.006	0.051	148	1.789	1.74	34%
Nov	3.2	4.6	0.080	0.008	0.072	311	5.309	5.24	73%
Dec	3.6	4.6	0.091	0.009	0.082	311	6.029	5.95	73%

Table 7.2-1: Monthly selenium current conditions and load reductions necessary to meet the applicable water quality standard.

7.3 TMDL for Total Uranium

For the total uranium TMDL, a 10 percent Margin of Safety was included in the TMDL. The TMDL is expressed as a Load Allocation, meaning that all pollutant reduction necessary to attain standards would have to be accomplished through reductions of non-point source pollution.

Month	Median (cfs)	U Standard (ug/L)	U TMDL (allowable load, lbs/day)	10% MOS (lbs/day)	Load Allocation (, lbs/day)	Current Conditions (ambient WQ, ug/L)	Current Load (lbs/day)	Load Reduction (lbs/day)	Percent Reduction
Jan	3.5	30	0.562	0.056	0.506	68	1.273	0.768	2%
Feb	3.5	30	0.572	0.057	0.515	68	1.297	0.782	2%
Mar	3.4	30	0.545	0.055	0.491	71	1.291	0.800	2%
Apr	2.6	30	0.420	0.042	0.378	62	0.868	0.490	1%
May	5.0	30	0.804	0.080	0.724	32	0.858	0.134	0%
Jun	13.9	30	2.258	0.226	2.032	41	3.086	1.054	1%
Jul	6.0	30	0.966	0.097	0.869	43	1.385	0.515	1%
Aug	4.5	30	0.724	0.072	0.652	45	1.086	0.435	1%
Sep	2.2	30	0.349	0.035	0.314	53	0.611	0.297	1%
Oct	2.2	30	0.364	0.036	0.327	60	0.727	0.400	1%
Nov	3.2	30	0.513	0.051	0.462	65	1.111	0.650	1%
Dec	3.6	30	0.581	0.058	0.523	68	1.317	0.794	2%

Table 7.3-1: Monthly uranium current conditions and load reductions necessary to meet the applicable water quality standard

8.0 Restoration Planning and Implementation Process

There is no known restoration planning for the Boggs Creek watershed. Because there are no known discharges associated with selenium, zinc and uranium impairments, regulatory mechanisms (NPDES or CDPS permits) are not an appropriate tool. The most recent (December 2012) water quality management plan for the area points out the source(s) are unknown and further monitoring data is needed.

A rather robust selenium study has been conducted in the lower Arkansas watershed, *Assessing and Modeling Irrigation-Induced Selenium in the Strem-Aquifer System of the Lower Arkansas River Valley, Colorado* (Gates, T.K., et. al, 2009) While data collection for the Gates study did not include Boggs Creek specifically, the selenium transport attributed to groundwater influence and geology of the area is the same. The study demonstrates a strong correlation between selenium and uranium in groundwater, and powerful relationships with nitrate in groundwater. The relationship to nitrate from fertilizers, and degree to which selenium depends on oxidation, suggests selenium in surface water can be reduced through nitrate control using best management practices (BMPs) in irrigated agriculture.

9.0 Public Involvement

Boggs Creek was initially included on the 2002 303(d) list of impaired waters in Colorado based upon water quality data, and remained subsequent lists, including the

2012 303(d) list. The development of the 303(d) list is a public process involving solicitation from the public of candidate waterbodies, formation of a technical review committee comprised of representatives of both the public and private sector, and a public hearing before the Colorado Water Quality Control Commission. In an effort to engage local interest, the Division presented information to local groups including Pueblo Area Council of Governments (PACOG) and Arkansas and Fountain Coalition for Urban River Evaluation (AF CURE). The presentation(s) took place in the spring of 2015 and included general information on the TMDL development process, as well as identify specific TMDLs the Division is currently in process of completing.

The TMDL report was also public noticed. The TMDL was made available for public review and comment during a 30 day public notice period in September, 2015. Notice was provided in the Colorado Water Quality Information Bulletin and the draft TMDL was posted on the Division TMDL webpage.

10.0 References

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APPENDIX A – Data collected by the Water Quality Control Division

Sample Collection Date	Selenium (µg/L)	Sample Collection Date	Uranium (µg/L)
3/17/1998	16	3/17/1998	71
3/21/1998	180	6/2/1998	120
6/2/1998	420	**6/2/1998**	**140**
11/19/1998	330	11/19/1998	64
5/4/2000	200	**11/19/1998**	**65**
6/27/2000	380	8/10/2005	45
7/25/2000	130	4/4/2006	62
8/23/2000	140	6/6/2006	40
10/3/2000	170	5/11/2010	32
11/6/2000	200	6/21/2010	41
8/10/2005	82	10/6/2010	60
2/13/2006	210	5/18/2012	86.5
4/4/2006	141		
6/6/2006	0		
5/11/2010	57.5		
6/21/2010	13		
8/18/2010	20		
10/6/2010	21		
2/15/2011	330		
5/25/2011	30		
5/18/2012	20.5		